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(54) Pulsed arc welding method and apparatus

Impulslichtbogenschweissen und -vorrichtung

Méthode et appareillage de soudage à l'arc à courant pulsé

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- **PATENT ABSTRACTS OF JAPAN vol. 6, no. 117 (M-139), 30 June 1982 & JP 57 044472 A (MITSUBISHI ELECTRIC CORP), 12 March 1982,**

EP 0 774 317 B1

Description

[0001] The present invention relates to a pulsed arc welding method and apparatus according to the preamble of the independed claims, in which a droplet of a consumable electrode is transferred to a base metal in gas shield. Such a method and apparatus are known from JP-A-623547.

[0002] There is a pulsed arc welding apparatus disclosed in JP-A-6-23547 as this sort of technique. In this apparatus, a short circuit generated by that a wire and a base metal come into contact with each other by means of the droplet of the wire is detected, the timing of generation is decided whether it is too early, appropriate or too late for the pulse period, and pulse parameters are set automatically so that a short circuit is made properly.

SUMMARY OF THE INVENTION

[0003] It is an object of the present invention to provide a pulsed arc welding method and apparatus capable of always maintaining a proper arc state even when short circuit generation is changed.

[0004] In order to achieve the above-mentioned object, a first aspect of the present invention exists in that a pulsed arc welding method detects the amount of time when a short circuit is being generated by melting of the consumable electrode, and controls an arc length so that a mean value or an integrated value of this amount of time corresponds to a target value.

[0005] When the mean value or the integrated value of the short circuit time is larger than the target set value, the supply time of a base current is decreased in accordance with the difference therebetween, and, when the value of the short circuit time is smaller, the supply time of the base current is increased. In this way, it is possible to maintain the arc length in an optimum state only by controlling the supply time of the base current.

[0006] When the mean value or the integrated value of the short circuit time is larger than the target value, the supply time of the base current is decreased and the supply period of the pulse current is increased at the same time in accordance with the difference therebetween and, when the mean value or the integrated value is smaller, the supply time of the base current is increased and the supply period of the pulse current is decreased at the same time. In this manner, the arc length is maintained in an optimum state with the supply time of the base current and the supply period of the pulse current.

[0007] When it is required to compensate for resistance generation of heat produced when the consumable electrode projects beyond a predetermined length, respective supply periods of the base current and the pulse current are decreased in case the mean value or the integrated value of the short circuit time is larger than a target value, in accordance with the difference therebetween, and respective supply periods of the base current and the pulse current are increased in case they are smaller than the target value.

[0008] When the mean value or the integrated value of the short circuit time is larger than a target value, the supply period of the pulse current is decreased in accordance with the difference therebetween, and, when it is smaller than the target value, the supply period of the pulse current is increased. In this manner, it is also possible to maintain the arc length in an optimum state by controlling the supply period of the pulse current.

[0009] A second aspect of the present invention exists in that a pulsed arc welding apparatus comprises a short circuit detecting circuit for detecting the amount of time when a short circuit is being produced between a consumable electrode and a base metal by melting of the consumable electrode, a comparison circuit for comparing the integrated value or the mean value of the short circuit generating time detected by the short circuit detecting circuit with a target value, and a control circuit for controlling at least either one of the supply time of the pulse current and the supply time of the base current in accordance with the result of comparison by the comparison circuit.

[0010] The comparison circuit has a base time setting unit for setting the supply time of the base current, a pulse width setting unit for setting the supply time of the pulse current, an adder for obtaining the difference between the short circuit time detected by the short circuit detecting circuit and the predetermined short circuit set time, an integrated/mean value calculator for calculating the integrated value or the mean value of the difference sent from the adder, a base time regulator for increasing or decreasing the supply time of the base current from the base time setting unit in accordance with the integrated value or the mean value so as to obtain the time for ending to supply the base current, a selection switch which closes when the integrated value or the mean value is received from the integrated/mean value calculator, and a pulse width regulator for increasing or decreasing the supply time of the pulse current from the pulse width setting unit in accordance with the integrated value or the mean value so as to obtain the time for terminating the supply of the pulse current. With this, the supply time of the pulse current and the base current is controlled thereby to maintain the arc length in an optimum state.

[0011] Further, the comparison means has a base time setting unit for setting the supply time of the base current, a pulse width setting unit for setting the supply time of the pulse current, an adder for obtaining the difference between the short circuit time detected by the short circuit detecting circuit and the predetermined short circuit setting time, an integrated/mean value calculator for calculating the integrated value or the mean value of the difference sent from the

adder, and a pulse width regulator for increasing or decreasing the supply time of the pulse current from the pulse width setting unit in accordance with the integrated value or the mean value so as to obtain the time for terminating the supply of the pulse current. With this, it is possible to maintain the arc length in an optimum state only by controlling the supply time of the pulse current.

[0012] Furthermore, the comparison means has a base time setting unit for setting the supply time of the base current, a pulse width setting unit for setting the supply time of the pulse current, an adder for obtaining the difference between the short circuit time detected by the short circuit detecting circuit and the predetermined short circuit setting time, an integrated/mean value calculator for calculating the integrated value or the mean value of the difference sent from the adder, a base time regulator for increasing or decreasing the supply time of the base current from the base time setting unit in accordance with the integrated value or the mean value so as to obtain the time for ending to supply the base current, a first selection switch which is closed when the integrated value or the mean value is received from the integrated/mean value calculator, a first pulse width regulator for receiving the pulse current supply time from the pulse width setting unit in accordance with the integrated value or the mean value when a second selection switch is in a first state, decreasing the pulse width when the integrated value or the mean value shows a positive value and increasing the pulse width when the integrated value or the mean value shows a negative value, and a second pulse width regulator for receiving the pulse current supply time from the pulse width setting unit in accordance with the integrated value or the mean value when the second selection switch is in a second state, increasing the pulse width when the integrated value or the mean value shows a positive value and decreasing the pulse width when the integrated value or the mean value shows a negative value. With this, it is possible to select necessity or unecessity of compensation for resistance generation of heat produced by projection of a consumable electrode.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013]

Fig. 1 is a block diagram showing a first embodiment of a pulsed arc welding apparatus according to the present invention;
Fig. 2 is a waveform diagram showing a current at time of welding;
Fig. 3 is an explanatory diagram for explaining short circuit time;
Fig. 4 is a block diagram showing another embodiment of a pulsed arc welding apparatus according to the present invention;
Fig. 5 is a block diagram showing still another embodiment of a pulsed arc welding apparatus according to the present invention; and
Fig. 6 is a flow chart for explaining a pulsed arc welding method according to the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0014] Fig. 1 is a block diagram of a pulsed arc welding apparatus in which a pulsed arc welding method is executed according to an embodiment of the present invention. In Fig. 1, a reference numeral 1 represents a base metal, 2 a welding wire, and 3 a welding wire feed roller for feeding the welding wire at a predetermined speed. 5 indicates a primary rectifier for converting commercial alternating current to direct current working as a power source for welding, and 6 indicates an inverter circuit. This inverter circuit 6 is constituted using a switching element such as a field effect transistor (FET), and converts direct current outputted from the primary rectifier 5 into predetermined alternating current. 7 represents a transformer, 8 represents a secondary rectifier for rectifying an alternating current output of the transformer 7, and 9 represents a direct current reactor for smoothing the output of the secondary rectifier 8 and supplying the output to the welding wire. A secondary winding is applied to the direct current reactor 9, and detects a short circuit generated when the point of the welding wire 2 and the base metal 1 come into contact with each other by the droplet of the welding wire during welding.

[0015] 10 represents a pulse width modulator (PWM) for determining ON/OFF time of the inverter circuit 6, and 11 represents a pulse control circuit for controlling a pulse width of the PWM 10. 12 represents a pulse voltage setting unit for setting pulse voltage V_p for generating a pulse current in pulsed arc welding, and 13 represents a base voltage setting unit for setting base voltage V_b for generating the base current in a similar manner, and these respective voltage V_p and V_b are outputted to the pulse control circuit 11. 14 represents a pulse width regulator for regulating a pulse width (a pulse voltage application period) in pulsed arc welding, 15 represents a pulse width setting unit for setting a pulse width P_w concerned, 16 represents a base time regulator for also regulating the base time (a base voltage application period) in pulsed arc welding, and 17 represents a base time setting unit for setting base time T_b concerned.

[0016] In this way, the base time T_b is started when it is detected that the pulse width P_w is ended, and the pulse width P_w is started when it is detected that the base time T_b is ended (which is related to a period end signal S_{14} of

the pulse width and a period end signal S_{16} of the base time). The pulse control circuit 11 is operated so that outputs determined by pulse voltage V_p in the period of the pulse width P_w and determined by base voltage V_b in the period of the base time may be obtained.

[0017] 20 represents a short circuit time detector for detecting continuation time of short circuit T_s described above generated during welding. This short circuit time detector 20 receives induced voltage generated in the secondary winding applied to the direct current reactor 9 thereby to detect the short circuit time T_s. The short circuit time T_s and the induced voltage concerned will be described later. 21 represents a short circuit time setting unit for setting a target value T_j of the short circuit time T_s, 22 represents an adder for receiving the short circuit time T_s detected by the short circuit time detector 20 and the target value T_j which has been set in the short circuit time setting unit 21 and computing the difference (T_s-T_j) between both, 23 represents an integrated/mean value calculator for adding up $[\Sigma(T_s-T_j)]$ the output of the adder 22, and 24 represents a selection switch for inputting the integrated value outputted from the integrated/mean value calculator 23 into the pulse width regulator 14 and selecting whether the pulse width P_w is to be regulated or not. Besides, the integrated/mean value calculator 23 is illustrated in Fig. 1 so as to obtain the integrated value, but the mean value is obtainable when it is used, by dividing the integrated value by predetermined time or number of times.

[0018] Here, the above-mentioned short circuit time T_s will be explained with reference to Fig. 2 and Fig. 3. Fig. 2 is a diagram showing the current at time of welding, in which the axis of abscissas represents time and the axis of ordinates represents current. In pulsed arc welding, a large current (pulse current) I_p is outputted during the period of the pulse width P_w and a base current I_b is outputted during the base period T_b following the period of the pulse width P_w as shown, thereby to perform welding. In the present embodiment, the pulse current I_p is outputted based on the pulse voltage V_p which is set by the pulse voltage setting unit 12 and the base current I_b is outputted based on the base voltage V_b which is set by the base voltage setting unit 13 as described above. Further, basic output periods thereof are determined by set values P_w and T_b of the pulse width setting unit 15 and the base time setting unit 17, respectively.

[0019] In case the above-mentioned short circuit is produced when welding is being executed in the embodiment described above, an irregular triangular wave is generated in the welding current 8 as shown in the figure by arc length self-control operation in the power source for welding having a constant voltage characteristic. The current increase portion of this triangular wave corresponds to the short circuit period (short circuit time) T_s. Such short circuit time T_s has a relative length as illustrated depending on the generating state of the short circuit. The relationship between the short circuit time T_s and the arc voltage is shown in Fig. 3 with the feeding speed of the welding wire as a parameter.

[0020] Fig. 3 is a diagram explaining the short circuit time T_s, in which the axis of ordinates represents the arc voltage (which is determined by the base time T_b) and the axis of abscissas represents the mean value of the short circuit time T_s. In Fig. 3, the solid line indicates the mean value of the short circuit time T_s in case the welding wire feeding speed is low, a broken line indicates the mean value of the short circuit time T_s in case the welding wire feeding speed is high, and a dotted line indicates the mean value of the short circuit time T_s in case the welding wire feeding speed lies in-between. As it is apparent from Fig. 3, the mean value in a predetermined period of the short circuit time T_s decreases with the increase of the arc voltage, and, when a predetermined arc voltage is exceeded, the short circuit is not generated, but the mean value of the short circuit time T_s becomes 0. Namely, since the distance between the low end surface of the droplet and the base metal 1 is large when the arc voltage is high, no short circuit is generated. Further, it is comprehended that the relationship between the arc voltage and the mean value of the short circuit time T_s remains almost the same even if the welding wire feeding speed is changed, and although the arc voltage that the short circuit becames no longer produced due to the welding wire feeding speed is different, there is no by difference in the tendency thereof.

[0021] The short circuit time T_s has been explained above. It may be concluded from the foregoing that, when the pulse voltage V_p, the base voltage V_b, and the pulse width P_w are set in accordance with the material quality and the diameter of the welding wire 2 to be used, and the welding wire feeding speed (which relates to welding current), the arc voltage (which relates to base time T_b) in accordance with the welding work are selected, and the target value T_j of the short circuit time T_s is selected, and the short circuit time T_s and the target value T_j are compared with each other thereafter (the integrated value of the difference between both is used as described above in the present embodiment) and the short circuit time T_s is brought to close to the target value T_j, it is possible to always maintain an appropriate short circuit state, such as a state that a minute short circuit in a very short time is not produced, automatically even when an erroneous arc voltage setting has been made or even when a change in welding conditions, disturbance for the arc condition or the like are produced.

[0022] Here, the determination of the target value T_j of the short circuit time T_s will be explained. In the pulsed arc welding, the condition for obtaining a predetermined welding quality is not limited to one, but there are various conditions. Further, the arc state (welding conditions) that is easy to work is different depending on a worker who performs welding work practically. Since the target value T_j is a value for determining which is better, the arc voltage is set higher (the short circuit time T_s is short) or the arc voltage is set lower (the short circuit time T_s is long), it is desirable to make the target value T_j freely selectable by a worker from a viewpoint of convenience in use for the worker.

[0023] Next, another embodiment of a pulsed arc welding apparatus will be explained with reference to Fig. 4. The difference of the pulsed arc welding apparatus shown in Fig. 4 from what is shown in Fig. 1 exists in that the base time regulator 16 and the selection switch 24 shown in Fig. 1 are nonexistent. Namely, the integrated/mean value of the difference between the short circuit time T_s and the target value T_j from the integrated/mean value calculator 23 is supplied directly to the pulse width regulator 14. Further, a signal showing during the base time is supplied to the pulse control circuit 11 from the base time setting unit 17, and on the other hand, a signal showing the base period is supplied to the short time setting unit 21. Further, the base time setting unit 17 sends a signal showing that the base period is ended to the pulse width regulator 14, the pulse period is started with the signal, and a signal showing during the pulse period is sent to the pulse control circuit 11. When a predetermined pulse period ($P_w \pm \Delta P_w$) is ended, the end signal thereof is sent from the pulse width regulator 14 to the base time setting unit 17, and the base time setting unit 17 sends a signal showing the base period to the pulse control circuit 11. With this, it is possible to control the arc length only by regulating the pulse width P_w. Since other structures are the same as those of what is shown in Fig. 1, description thereof is omitted.

[0024] Furthermore, another embodiment of a pulsed arc welding apparatus is shown in Fig. 5. The difference of the pulsed arc welding apparatus shown in Fig. 5 from what is shown in Fig. 1 is that a pulse width regulator 14' and a selection switch 24' are added further to what is shown in Fig. 1. With this, when it is required to compensate for resistance generation of heat due to the projected length of the welding wire 2 in addition to control the arc length with the base time T_b and the pulse width P_w as explained with reference to Fig. 1, the selection switch 24' is changed over to the side of the pulse width regulator 14', and the pulse width regulator 14' decreases the pulse width P_w supplied through the selection switch 24' by a value ΔP_w conversely to the integration by the pulse width regulator 14 when the integrated value $\Sigma(T_s-T_j)$ supplied through the selection switch 24 is positive, and the pulse width regulator 14' increases the pulse width P_w from the selection switch 24' by the value ΔP_w when the integrated value $\Sigma(T_s-T_j)$ is negative. Since other structures shown in Fig. 5 are the same as those shown in Fig. 1, description thereof is omitted.

[0025] Next, the operation of the present embodiment shown in Fig. 1 will be described based on Fig. 6. Besides, the apparatuses shown in Fig. 4 and Fig. 5 will be described later. First, in a step 60, respective values are set to the pulse voltage setting unit 12, the base voltage setting unit 13, the pulse width setting unit 15, the base time setting unit 17 and the short circuit time setting unit 21, thus resetting a counter. Welding is started in a step 61. At the start, a pulse current and a base current shown in Fig. 2 flow in accordance with these respective set values.

[0026] Induced voltage is generated in the secondary winding of the direct current reactor 9 during welding. When it is assumed that the inductance of the secondary winding concerned is L_2, a current passing therethrough is i, and the time is t, the induced voltage e_2 is expressed by the following expression.

$$e_2 = -L_2 \bullet (di/dt) \qquad (1)$$

[0027] When a short circuit is generated by a droplet, the induced voltage e_2 shows a negative value since the current increases during the short circuit period, and, when the short circuit is opened, the induced voltage shows a positive value since the current decreases. However, since the induced voltage e_2 also shows a negative value at the leading period of pulse voltage V_p, in a step 62, a stop signal S_{20} is outputted to the short circuit time detector 20 from the pulse width regulator 14 thereby to stop the detection operation thereof during the period of the pulse width P_w so that no detection is made in this case. Then, when the pulse period is ended, in a step 63, the short circuit time detector 20 receives the induced voltage e_2 and obtains the time during which the induced voltage e_2 shows a negative value. This is the short circuit time.

[0028] On the other hand, the base time regulator 16 outputs a signal S_{21} for notifying that the base time T_b has been started to the short circuit time setting unit 21, and in a step 64, the short circuit time setting unit 21 outputs the target value T_j to the adder 22 during a predetermined time (the time in which generation of a short circuit is anticipated) from the input of the signal S_{21}. In a step 65, the adder 22 receives the short circuit time T_s from the short circuit time detector 20 and the target value T_j from the short circuit time setting unit 21, computes the difference (T_s-T_j) between both and outputs the result to the integrator 23. Namely, the difference (T_s-T_j) between the short circuit time T_s and the target value T_j in the period (P_w+T_b) is outputted from the adder 22 in every pulse period of (P_w+T_b). In a step 66, the integrator 23 integrates the difference (T_s-T_j) concerned successively and obtains the integrated value $\Sigma(T_s-T_j)$. In a step 67, when the base time has been ended, the processing proceeds ahead. In a step 70, when the selection switch 24 is kept opened, the integrated value $\Sigma(T_s-T_j)$ obtained by the integrated/ mean value calculator 23 is outputted only to the base time regulator 16. This is what is called a case that the arc length is controlled only by the base time T_b. Here, in a step 68, a counter N is incremented, and, in a step 69, the counter is determined. When the counter shows the maximum value, in steps 71 and 72, the base time regulator 16 increases or decreases the present base time T_b in accordance with the integrated value concerned when the integrated value $\Sigma(T_s-T_j)$ is inputted from the

integrated/mean value calculator 23, and sets such new base time that the short circuit time T_s becomes the target value T_j, i.e., the integrated value $\Sigma(T_s\text{-}T_j)$ becomes 0. An instance of this operation will be given. Now, when it is assumed that the present base time is T_{b00} and a control constant is α, the operation of new base time T_{b00} is performed in accordance with the following expression.

$$T_{b00} = T_{b0} - \alpha\bullet\Sigma(T_s\text{-}T_j) = T_{b0} - \Delta T_b \qquad (2)$$

[0029] Namely, when the integrated value $\Sigma(T_s\text{-}T_j)$ is positive (the integrated value of the short circuit time T_s is larger than the integrated value of the target value T_j), it is sufficient to decrease the mean value of the short circuit time T_s. For such a purpose, it is apparent to increase the arc voltage as it is apparent from Fig. 3. Thus, time ΔT_b in accordance with the integrated value $\Sigma(T_s\text{-}T_j)$ is decreased from the present base time so as to obtain new base time. Conversely, when the integrated value $\Sigma(T_s\text{-}T_j)$ is negative, time ΔT_b in accordance with the integrated value $\Sigma(T_s\text{-}T_j)$ is added to the present base time so as to obtain new base time. Besides, the control constant α is determined taking the material quality of the welding wire 2, the velocity of response of control or the like into consideration. Then, counters N, Σ are reset in a step 73.

[0030] The new base time T_{b00} obtained as described above is outputted to the pulse control circuit 11 in a step 72, and the pulse control circuit 11 outputs the ON/OFF command to a pulse width modulator 10 in accordance with this new base time T_{b00}, thus increasing or decreasing the base time. Further, in a period including this new base time T_{b00}, the short circuit time T_s is detected again by means of the short circuit time detector 20 and the above-mentioned control operation is repeated.

[0031] The above-mentioned means is one that controls the base time T_b only with the selection switch 24 kept opened, but it is capable of performing more effective control by controlling the pulse width P_w in addition to the base time T_b. When such control is performed, the selection switch 24 is closed. By closing the selection switch 24, the integrated value $\Sigma(T_s\text{-}T_j)$ operated by the integrated/mean value calculator 23 is inputted to the base time regulator 16 and also to the pulse width regulator 14 at the same time. The pulse control circuit 11 also increases or decreases the pulse width P_w similarly to the base time regulator 16. When it is not required in a step 74 to compensate for the resistance generation of heat due to the extension length of the welding wire 2, however, in a step 75, conversely to the base time regulator 16 the pulse width P_w is increased (P_w+ΔP_w) by a value ΔP_w in accordance with the integrated value $\Sigma(T_s\text{-}T_j)$ in case the integrated value $\Sigma(T_s\text{-}T_j)$ is positive, and the pulse width P_w is decreased (P_w-ΔP_w) by the value ΔP_w in accordance with the integrated value $\Sigma(T_s\text{-}T_j)$ in case the integrated value $\Sigma(T_s\text{-}T_j)$ is negative. This is carried out by making close a selection switch 24' to the pulse width regulator 14. In a step 76, the arc length is controlled with the base time T_{b00} and the pulse width ($P_w \pm \Delta P_w$).

[0032] When it is required to compensate for resistance generation of heat due to the extension length of the welding wire 2, in a step 74, it is recommended in a step 77 to decrease the pulse width P_w by a value ΔP_w when the integrated value $\Sigma(T_s\text{-}T_j)$ is positive and the pulse width P_w is increased by the value ΔP_w when the integrated value $\Sigma(T_s\text{-}T_j)$ is negative conversely to the above. This is carried out by making close the selection switch 24' to the pulse width regulator 14'. This corresponds to the pulsed arc welding apparatus shown in Fig. 5. Since the pulsed arc welding apparatus shown in Fig. 4 can be comprehended easily from the operation explained based on Fig. 1, description thereof is omitted.

[0033] Since it has been made in the present embodiment to regulate the base time or the base time and the pulse width so as to bring the short circuit time generated during welding closer to the target value, it is possible to always maintain an appropriate short circuit state automatically even when a change in the welding condition or disturbance on the arc state and so on are produced, thus making it possible to secure a high welding quality easily and to uniformalize the welding quality.

[0034] Further, a considerable amount of skill has been required for setting the arc voltage in order to obtain an appropriate arc state in conventional pulsed arc welding. In the present embodiment, however, the skill of a worker is not required since inappropriate setting of the arc voltage is corrected automatically if any.

[0035] Furthermore, it is required to set appropriate arc voltage in accordance with the welding current in conventional pulsed arc welding, but, since the short circuit state is controlled in the present embodiment, it is not required to vary setting in accordance with the welding current (wire feeding speed), and the burden is largely improved for a worker.

[0036] A Table 1 shown below shows the result of welding in which the apparatus shown in Fig. 1 has been used. In this case, welding in which the welding current (i.e., welding wire feeding speed) and the initial voltage (i.e., the initial set value of the base time) has been performed using JIS YGW 17 having a diameter of 1.2 mm for the welding wire and assuming that the pulse voltage V_p = 39 V, the base voltage V_b = 8.5 V, the pulse width P_w = 1.4 ms, the welding wire extension length (EXT) = 15 mm, the welding speed = 750 mm/min. and the target value T_j = 0.02 ms. Besides, the symbols "○", "Δ", "▲" and "X" in the table show goodness of the result of welding in this order, and "○"

shows the best and "X" shows inferiority. (The same is applied to a Table 2 and a Table 3 shown later.)

Table 1

Welding current (A)	Initial arc voltage (V)	No control		T_b control		(T_b+P_w) contrtol	
		Convergent arc voltage (V)	Deci-sion	Convergent arc voltage (V)	Deci-sion	Convergent arc voltage (V)	Deci-sion
100 (3.5 m/min)	18.5	18.5	×	21.3~21.5	○	20.8~21.0	○
	20.0	20.0	▲	21.0~21.5	○	21.3~21.5	○
	21.5	21.5	○	21.0~21.5	○	21.0~21.5	○
	23.0	23.0	▲	21.0~21.3	○	21.5	○
	24.5	24.5	×	21.0~21.3	○	21.5	○
150 (5.3 m/min)	21.0	21.0	×	23.5~24.0	○	24.5	○
	22.5	22.5	▲	34.5~24.0	○	24.0~24.5	○
	24.0	24.0	○	23.5~24.0	○	23.2~24.0	○
	25.5	25.5	▲	23.5~24.0	○	24.0~24.2	○
	27.0	27.0	×	23.5~24.0	○	23.8~24.0	○

- Cont'd -

Table 1 (Cont'd)

Welding current (A)	Initial arc voltage (V)	No control		T_b control		(T_b+P_w) contrtol	
		Convergent arc voltage (V)	Decision	Convergent arc voltage (V)	Decision	Convergent arc voltage (V)	Decision
200 (7.7 m/min)	22.5	22.5	×	25.5~26.0	○	25.0, 25.5	○
	24.0	24.0	▲	25.5~26.0	○	25.0~25.5	○
	25.5	25.5	○	25.3~25.5	○	26.0	○
	27.0	27.0	▲	25.8~26.0	○	25.8~26.0	○
	28.5	28.5	×	25.8~26.0	○	25.8~26.0	○
250 (8.7 m/min)	23.5	23.5	×	26.2~26.5	○	26.5	○
	25.0	25.0	▲	26.0	○	26.5	○
	26.5	26.5	○	26.3~26.5	○	26.0~26.5	○
	27.5	27.5	▲	26.0	○	28.5	○
	28.5	28.5	×	26.0~26.3	○	26.5	○

- Cont'd -

Table 1 (Cont'd)

Welding current (A)	Initial arc voltage (V)	No control		T_b control		(T_b+P_w) contrtol	
		Convergent arc voltage (V)	Decision	Convergent arc voltage (V)	Decision	Convergent arc voltage (V)	Decision
300 (11.8 m/min)	24.0	24.0	×	27.2~27.5	○	28.5	○
	25.0	25.0	▲	27.2~27.5	○	28.2	○
	26.0	26.0	△	27.5	○	28.0	○
	27.0	27.0	○	27.2~27.5	○	27.8	○

Welding wire: JIS YGV17•ϕ1.2 mm

T_j = 0.02 ms, V_p = 39 V, V_b = 8.5 V, P_w = 1.4 ms,

Ext = 15 mm, Welding speed = 750 mm/min

[0037] In respective welding currents, the initial arc voltage has been varied within a range of an proper value ±3 V, but the arc voltage has been converged to proper arc voltage automatically in every case. Besides, a method of controlling the base time T_b only and a method of performing automatic control in which the pulse width P_w is increased when the integrated value $\Sigma(T_s\text{-}T_j)$ is positive and the pulse width P_w is decreased when the integrated value $\Sigma(T_s\text{-}T_j)$ is negative along with automatic control of the base time T_b have been examined as the control method, but satisfactory results have been obtained in either control method.

[0038] A Table 2 below shows another result of welding. In this case, welding similar to the case of the Table 1 has been performed using JIS YGW 15 having a diameter of 1.6 mm for the welding wire and assuming that the pulse voltage V_p = 43 V, the base voltage V_b = 10 V, the pulse width P_w = 1.9 ms, the welding wire extension length (EXT) = 20 mm, the welding speed = 750 mm/min, and the target value T_j = 0.03 ms. In this case, satisfactory results have also been obtained in either case of automatic control of the base time and automatic control of the base time and the pulse width.

Table 2

Welding current (A)	Initial arc voltage (V)	No control		T_b control		(T_b+P_w) contrtol	
		Convergent arc voltage (V)	Deci-sion	Convergent arc voltage (V)	Deci-sion	Convergent arc voltage (V)	Deci-sion
150 (2.7 m/min)	19.5	19.5	×	22.5~23.0	○	22.5~23.0	○
	21.0	21.0	▲	22.5~23.0	○	22.5	○
	22.5	22.5	○	22.5	○	22.0~22.5	○
	24.0	24.0	▲	22.5~23.0	○	22.0~22.5	○
	25.5	25.5	×	22.5~23.0	○	22.5~23.0	○
200 (3.5 m/min)	21.0	21.0	×	22.8~23.2	○	23.0~23.5	○
	22.5	22.5	▲	23.0~23.5	○	23.0~23.5	○
	24.0	24.0	○	22.5~23.0	○	23.0~23.5	○
	25.5	25.5	▲	22.5~23.0	○	23.5~24.0	○
	27.0	27.0	×	23.0~23.5	○	23.5~24.0	○

- Cont'd -

Table 2 (Cont'd)

Welding current (A)	Initial arc voltage (V)	No control		T_b control		(T_b+P_w) contrtol	
		Convergent arc voltage (V)	Deci-sion	Convergent arc voltage (V)	Deci-sion	Convergent arc voltage (V)	Deci-sion
250 (5.3 m/min)	22.0	22.0	×	25.5~26.0	○	25.0, 25.5	○
	23.5	23.5	▲	24.5~25.0	○	24.5~25.0	○
	25.0	25.0	○	25.0~25.3	○	25.0~25.5	○
	26.5	26.5	▲	24.5~25.0	○	24.5~25.0	○
	28.0	28.0	×	25.0~25.5	○	24.5~25.0	○
300 (5.8 m/min)	23.0	23.0	×	25.5~26.0	○	26.0~26.3	○
	24.5	24.5	▲	25.8~26.3	○	25.8~26.2	○
	26.0	26.0	○	25.5~26.0	○	26.0~26.2	○
	27.5	27.5	▲	25.5~26.0	○	26.0~26.2	○
	29.0	29.0	×	25.5~26.0	○	26.0~26.3	○

- Cont'd -

Table 2 (Cont'd)

Welding current (A)	Initial arc voltage (V)	No control		T_b control		(T_b+P_w) contrtol	
		Convergent arc voltage (V)	Decision	Convergent arc voltage (V)	Decision	Convergent arc voltage (V)	Decision
350 (6.5 m/min)	24.0	24.0	×	26.5~26.8	○	26.8~27.0	○
	25.5	25.5	▲	26.5~26.8	○	26.5~27.0	○
	27.0	27.0	○	26.5~27.0	○	26.0~26.5	○
	28.5	28.5	▲	26.8~27.0	○	26.5	○
	30.0	30.0	×	27.0~27.2	○	26.0~26.5	○

Welding wire: JIS YGV17•ϕ1.6 mm

T_j = 0.03 ms, V_p = 43 V, V_b = 10 V, P_w = 1.9 ms,

Ext = 20 mm, Welding speed = 750 mm/min

[0039] A Table 3 below shows another result of welding. In this case, the welding conditions are set the same as the Table 1, the automatic control of the base time and the automatic control of the pulse width are performed at the same time, and, in the automatic control of the pulse width, the pulse width Pw is decreased when the integrated value $\Sigma(T_s-T_j)$ is positive and the pulse width P_w is increased when the integrated value $\Sigma(T_s-T_j)$ is negative. In this case, it could also be confirmed that the arc voltage was all converged to proper arc voltage irrespective of the initial set value thereof.

Table 3

Initial arc set value			(T_b) control			(T_b+P_w) contrtol		
Set voltage (V)	T_b (ms)	P_w (ms)	Convergent arc voltage (V)	T_b (ms)	P_w (ms)	Convergent arc voltage (V)	T_b (ms)	P_w (ms)
21.0	7.8		24.3~24.5	4.7		25.3	3.5	1.34
22.5	6.3		24.5~25.0	4.4		25.0	3.9	1.40
24.0	5.4	1.6	24.0~24.5	4.7	1.6	24.5	4.0	1.46
25.5	4.0		24.0~24.5	4.8		24.5	5.0	1.66
27.0	3.5		24.0~24.5	4.6		24.5	4.8	1.74

Welding wire: JIS YGV17•ϕ1.2 mm, Welding wire feeding speed = 5.3 m/min(≒ 150 A)

Welding speed = 750 mm/min, Ext = 15 mm, V_p = 39 V, V_b = 8.5 V, *T_j = 0.02 ms

[0040] Besides, pulsed arc welding of a constant voltage system has been explained in the description of the present embodiment. However, it is apparent that the present invention is also applicable to pulsed arc welding of a constant current system. Further, the short circuit time has been described citing an instance of using the integrated value $\Sigma(T_s-T_j)$, i.e., an instance in which the integrated value of the short circuit time is compared with a predetermined value (integrated value of the target value T_j), but it may also be arranged so that only the short circuit time T_s is integrated and the mean value thereof is compared with the target value T_j.

Claims

1. A pulsed arc welding method for welding by supplying a pulse current and a base current alternately across a consumable electrode (2) and a base metal (1), comprising the steps of:

   detecting a time during which a short circuit produced by melting of said consumable electrode is generated;
   characterized in
   controlling arc length so that one of a mean value and an integrated value of the time corresponds to a target value.

2. A pulsed arc welding method according to Claim 1, wherein said arc length is controlled so that when one of said mean value and said integrated value is larger than said target value, a supply time of said base current is decreased in accordance with difference therebetween, and, when one of said mean value and said integrated value is smaller than said target value, a supply time of said base current is increased in accordance with difference therebetween.

3. A pulsed arc welding method according to Claim 1, wherein said arc length is controlled so that when one of said mean value and said integrated value is larger than said target value, a supply time of said base current is decreased and a supply period of said pulse current is increased simultaneously in accordance with difference therebetween, and when one of said mean value and said integrated value is smaller than said target value, a supply time of said base current is increased and a supply period of said pulse current is decreased simultaneously in accordance with difference therebetween.

4. A pulsed arc welding method according to Claim 1, wherein said arc length is controlled so that when one of said mean value and said integrated value is larger than said target value, respective supply periods of said base current and said pulse current are decreased in accordance with difference therebetween, and when one of said mean value and said integrated value is smaller than said target value, respective supply periods of said base current and said pulse current are increased in accordance with difference therebetween.

5. A pulsed arc welding method according to Claim 1, wherein said arc length is controlled so that when one of said mean value and said integrated value is larger than said target value, a supply period of said pulse current is increased in accordance with difference therebetween, and, when one of said mean value and said integrated value is smaller than said target value, a supply period of said pulse current is decreased in accordance with difference therebetween.

6. A pulsed arc welding apparatus for welding by supplying a pulse current and a base current alternately across a consumable electrode (2) and a base metal (1), comprising:

   short circuit detecting means (9, 20) for detecting a time during which a short circuit produced by melting said consumable electrode across said consumable electrode (2) and said base metal (1) is generated;

   characterized in further comprising

   comparison means (20, 21, 22, 23) for comparing one of an integrated value and a mean value of a short circuit generating time detected by the short circuit detecting means with a target value; and
   control means (11, 14, 16, 24) for controlling at least one of a supply time of said pulse current and a supply time of said base current in accordance with a result of the comparison by said comparison means.

7. A pulsed arc welding apparatus according to Claim 6, wherein said comparison means comprises:

   a base time setting unit (17) for setting the supply time of the base current;

a pulse width setting unit (15) for setting the supply time of the pulse current;
an adder (22) for obtaining difference between a short circuit time (T_s) detected by said short circuit detecting means (20) and a predetermined short circuit setting time;
an integrated/mean value calculator (23) for generating one of an integrated value and a mean value of the difference from said adder (22);
a base time regulator (16) at least one of increasing and decreasing the supply time of said base current from said base time setting unit (17) in accordance with one of said integrated value and said mean value and obtaining a time of ending to supply the base current;
a selection switch (24) which is closed when one of said integrated value and mean value from said integrated/mean value calculator (23) is received; and
a pulse width regulator (14) for receiving one of said integrated value and said mean value through said selection switch (24), at least one of increasing and decreasing the supply time of said pulse current from said pulse width setting unit (15), and obtaining a time for terminating the supply of the pulse current.

8. A pulsed arc welding apparatus according to Claim 6, wherein said comparison means comprises:

a base time setting unit (17) for setting the supply time of the base current;
a pulse width setting unit (15) for setting the supply time of the pulse current;
an adder (22) for obtaining difference between a short circuit time detected by said short circuit detecting means (20) and a short circuit setting time calculated in accordance with the supply time of the base current from said base time setting unit (17);
an integrated/mean value calculator (23) for generating one of an integrated value and a mean value of difference from said adder (22); and
a pulse width regulator (14) at least one of increasing and decreasing the supply time of said pulse current from said pulse width setting unit (15) in accordance with one of said integrated value and mean value, and obtaining a time of terminating the supply of the pulse current.

9. A pulsed arc welding apparatus according to Claim 6, wherein said comparison means comprises:

a base time setting unit (17) for setting the supply time of the base current;
a pulse width setting unit (15) for setting the supply time of the pulse current;
an adder (22) for obtaining difference between a short circuit time (T_s) detected by said short circuit detecting means (20) and a predetermined short circuit setting time;
an integrated/mean value calculator (23) for generating one of an integrated value and a mean value of the difference from said adder (22);
a base time regulator (16) at least one of increasing and decreasing the supply time of said base current from said base time setting unit (17) in accordance with one of said integrated value and said mean value and obtaining a time of ending to supply the base current;
a first selection switch (24) which is closed when one of said integrated value and mean value from said integrated/mean value calculator (23) is received;
a first pulse width regulator (14) for receiving one of said integrated value and said mean value through said first selection switch (24), receiving said pulse current supply time from said pulse width setting unit (15) when a second selection switch (24') is in a first state, and decreasing a pulse width when one of said integrated value and said mean value is positive and increasing a pulse width when one of the integrated value and the mean value is negative; and
a second pulse width regulator (14') for receiving one of said integrated value and said mean value through said first selection switch (24), receiving said pulse current supply time from said pulse width setting unit (15) when said second selection switch (24') is in a second state, and increasing a pulse width when one of said integrated value and said mean value is positive and decreasing a pulse width when one of the integrated value and the mean value is negative;

whereby said first and second pulse width regulators (14, 14') obtain a time for terminating the supply of the pulse current, respectively.

10. A pulsed arc welding apparatus according to Claim 6, wherein said short circuit detecting means, comparison means and control means are based on a constant voltage system.

11. A pulsed arc welding apparatus according to Claim 6, wherein said short circuit detecting means, comparison

means and control means are based on a constant current system.

Patentansprüche

1. Impulslichtbogenschweißverfahren zum Schweißen mittels Zuführung eines impulsartigen Stroms und eines Basisstroms abwechselnd über eine Verbrauchselektrode (2) und ein Basismetall (1) mit den Schritten:

   Erfassen einer Zeit, während der durch Schmelzen der Verbrauchselektrode ein Kurzschluß erzeugt wird,
   gekennzeichnet, durch
   Steuern der Bogenlänge so, daß der Mittelwert oder der integrierte Wert der Zeit einem Sollwert entspricht.

2. Impulslichtbogenschweißverfahren nach Anspruch 1, bei der die Bogenlänge so gesteuert wird, daß dann, wenn der Mittelwert oder der integrierte Wert größer als der Sollwert ist, die Zuführzeit des Basisstroms nach Maßgabe des Unterschieds verringert wird, und daß dann, wenn der Mittelwert oder der integrierte Wert kleiner als der Sollwert ist, die Zuführzeit des Basisstroms nach Maßgabe des Unterschieds erhöht wird.

3. Impulslichtbogenschweißverfahren nach Anspruch 1, bei dem die Bogenlänge so gesteuert wird, daß dann, wenn der Mittelwert oder der integrierte Wert größer als der Sollwert ist, die Zuführzeit des Basisstroms verringert wird und die Zuführperiode des Impulsstroms gleichzeitig nach Maßgabe des Unterschieds erhöht wird, wobei dann, wenn der Mittelwert oder der integrierte Wert kleiner als der Sollwert ist, die Zuführzeit des Basisstroms erhöht wird und gleichzeitig die Zuführperiode des Impulsstroms nach Maßgabe des Unterschieds verringert wird.

4. Impulslichtbogenschweißverfahren nach Anspruch 1, bei dem die Bogenlänge so gesteuert wird, daß dann, wenn der Mittelwert oder der integrierte Wert größer als der Sollwert ist, die Zuführperioden des Basisstroms und des Impulsstroms verringert werden nach Maßgabe des Unterschieds, und wenn der Mittelwert oder der integrierte Wert kleiner als der Sollwert ist, die Zuführperioden des Basisstroms oder des Impulsstroms nach Maßgabe des Unterschieds erhöht werden.

5. Impulslichtbogenschweißverfahren nach Anspruch 1, bei dem die Bogenlänge so gesteuert wird, daß dann, wenn der Mittelwert oder der integrierte Wert größer als der Sollwert ist, die Zuführperiode des Impulsstroms nach Maßgabe des Unterschieds erhöht wird, und bei dem dann, wenn der Mittelwert oder der integrierte Wert kleiner als der Sollwert ist, die Zuführperiode des Impulsstroms nach Maßgabe des Unterschieds verringert wird.

6. Impulslichtbogenschweißvorrichtung zum Schweißen durch Zuführen eines Impulsstroms und eines Basisstroms abwechselnd über eine Verbrauchselektrode (2) und ein Basismetall (1) mit

   einer Kurzschlußerfassungseinrichtung (9, 20) zum Erfassen einer Zeit, während der durch Schmelzen der Verbrauchselektrode zwischen der Verbrauchselektrode (2) und dem Basismetall (1) ein Kurzschluß erzeugt wird,
   weiter **gekennzeichnet durch**
   einer Vergleichseinrichtung (20, 21, 22, 23) zum Vergleichen des integrierten Werts oder des Mittelwerts der Kurzschlußerzeugungszeit, wie sie von der Kurzschlußerfassungseinrichtung erfaßt wird, mit einem Sollwert, und
   einer Steuerungseinrichtung (11, 14, 16, 24) zum Steuern zumindest der Zuführzeit des Impulsstroms oder der Zuführzeit des Basisstroms nach Maßgabe des Ergebnisses des Vergleichs **durch** die Vergleichseinrichtung.

7. Impulslichtbogenschweißvorrichtung nach Anspruch 6, bei der die Vergleichseinrichtung aufweist:

   eine Basiszeit-Setzeinheit (17) zum Setzen der Zuführzeit des Basisstroms;
   eine Impulsbreiten-Setzeinheit (15) zum Setzen der Zuführzeit des Impulsstroms;
   einen Addierer (22) zum Ermitteln des Unterschieds zwischen einer Kurzschlußzeit (T_s), wie sie von der Kurzschlußerfassungseinrichtung (20) erfaßt wird, und einer vorbestimmten Kurzschluß-Setzzeit;
   einen Rechner (23) zum Berechnen eines integrierten oder gemittelten Werts zum Erzeugen eines integrierten Werts oder eines Mittelwerts des Unterschieds vom Addierer (22);
   einen Basiszeitregler (16) zumindest zum Erhöhen oder Verringern der Zuführzeit des Basisstroms von der Basiszeit-Setzeinheit (17) nach Maßgabe des integrierten Werts oder des Mittelwerts und zum Ermitteln eines

Endzeitpunkts zur Zuführung des Basisstroms;
ein Auswahlschalter (24), der geschlossen ist, wenn der integrierte Wert oder der Mittelwert vom Rechner (23) für einen integrierten oder gemittelten Wert empfangen wird; und
einen Impulsbreitenregler (14) zum Empfangen des integrierten Werts oder des Mittelwerts über den Auswahlschalter (24), zumindest zum Erhöhen oder Verringern der Zuführzeit des Impulsstroms von der Impulsbreiten-Setzeinheit (15), und zum Ermitteln einer Zeit zum Beenden der Zuführung des Impulsstroms.

8. Impulslichtbogenschweißvorrichtung nach Anspruch 6, bei der die Vergleichseinrichtung aufweist:

eine Basiszeit-Setzeinheit (17) zum Setzen der Zuführzeit des Basisstroms;
eine Impulsbreiten-Setzeinheit (15) zum Setzen der Zuführzeit des Impulstroms;
einen Addierer (22) zum Ermitteln des Unterschieds zwischen einer Kurzschlußzeit, wie sie von der Kurzschlußerfassungseinrichtung (20) erfaßt wird, und einer Kurzschluß-Setzzeit, die nach Maßgabe der Zuführzeit des Basisstroms von der Basiszeit-Setzeinheit (17) berechnet wird;
einen Rechner (23) für einen integrierten oder gemittelten Wert zum Erzeugen eines integrierten Werts oder eines Mittelwerts des Unterschieds vom Addierer (22); und
einen Pulsbreitenregler (14) zumindest zum Erhöhen oder Verringern der Zuführzeit des Impulsstroms ausgehend von der Pulsbreiten-Setzeinheit (15) nach Maßgabe des integrierten Werts oder des Mittelwerts, und zum Ermitteln einer Zeit des Beendens des Zuführungsimpulsstroms.

9. Impulslichtbogenschweißvorrichtung nach Anspruch 6, bei der die Vergleichseinrichtung aufweist:

eine Basiszeit-Setzeinheit (17) zum Setzen der Zuführzeit des Basisstroms;
eine Pulsbreiten-Setzeinheit (15) zum Setzen der Zuführzeit des Impulsstroms;
einen Addierer (22) zum Ermitteln des Unterschieds zwischen einer Kurzschlußzeit (T_s), wie sie durch die Kurzschlußerfassungseinrichtung (20) erfaßt wird, und einer vorbestimmten Kurzschluß-Setzzeit;
einen Rechner (23) für einen integrierten bzw. gemittelten Wert zum Erzeugen eines integrierten Werts oder eines gemittelten Werts des Unterschieds vom Addierer (22),
einen Basiszeitregler (16) zumindest zum Erhöhen oder Verringern der Zuführzeit des Basisstroms ausgehend von der Basiszeit-Setzeinheit (17) nach Maßgabe des integrierten Werts oder des Mittelwerts und zum Ermitteln einer Zeit zum Beenden der Zuführung des Basisstroms;
einen ersten Auswahlschalter (24), der dann geschlossen ist, wenn der integrierte Wert oder der Mittelwert vom Rechner (23) für den integrierten bzw. gemittelten Wert empfangen wird; einen ersten Impulsbreitenregler (14) zum Empfangen des integrierten Werts oder des Mittelwerts über den ersten Auswahlschalter (24), zum Empfangen der Impulsstromzuführzeit von der Impulsbreitensetzeinheit (15), wenn sich ein zweiter Auswahlschalter (24') in einem ersten Zustand befindet, und zum Verringern einer Impulsbreite, wenn der integrierte Wert oder der Mittelwert positiv ist und zum Erhöhen der Impulsbreite, wenn der integrierte Wert oder der Mittelwert negativ ist; und
einen zweiten Impulsbreitenregler (14') zum Empfangen des integrierten Werts oder des Mittelwerts über den ersten Auswahlschalter (24) zum Empfangen der Impulsstromzuführzeit von der Impulsbreiten-Setzeinheit (15), wenn sich der zweite Auswahlschalter (24') in einem zweiten Zustand befindet, und zum Erhöhen einer Impulsbreite, wenn der integrierte Wert oder der Mittelwert positiv ist, und zum Verringern der Impulsbreite, wenn der integrierte Wert oder der Mittelwert negativ ist; wodurch der erste und der zweite Impulsbreitenregler (14, 14') einen Zeitpunkt zum Beenden des Zuführungsimpulsstroms erhalten.

10. Impulslichtbogenschweißvorrichtung nach Anspruch 6, bei der die Kurzschlußerfassungseinrichtung, die Vergleichseinrichtung und die Steuerungseinrichtung auf einem Konstantspannungssystem aufbauen.

11. Impulslichtbogenschweißvorrichtung nach Anspruch 6, bei der die Kurzschlußerfassungseinrichtung, die Vergleichseineinrichtung und die Steuerungseinrichtung auf einem Konstantstromsystem aufbauen.

Revendications

1. Procédé de soudage à l'arc à courant pulsé pour souder en faisant passer en alternance un courant pulsé et un courant de base dans une électrode consommable (2) et un métal de base (1), comprenant les étapes consistant à :

détecter un moment pendant lequel un court-circuit produit par la fusion de ladite électrode consommable est

généré, **caractérisé en ce que**
la longueur de l'arc est déterminée de façon qu'une valeur moyenne ou une valeur intégrée du moment corresponde à une valeur cible.

2. Procédé de soudage à l'arc à courant pulsé selon la revendication 1, dans lequel ladite longueur de l'arc est déterminée de façon que lorsque ladite valeur moyenne ou ladite valeur intégrée est supérieure à ladite valeur cible, la durée de l'application dudit courant de base soit réduite en fonction d'une différence entre celles-ci et que, lorsque ladite valeur moyenne ou ladite valeur intégrée est inférieure à ladite valeur cible, la durée d'application dudit courant de base augmente en fonction de la différence entre celles-ci.

3. Procédé de soudage à l'arc à courant pulsé selon la revendication 1, dans lequel ladite longueur de l'arc est commandée de façon que lorsque ladite valeur moyenne ou ladite valeur intégrée est supérieure à ladite valeur cible, la durée d'application dudit courant de base soit réduite et que la durée d'application dudit courant pulsé augmente simultanément en fonction de la différence entre celles-ci, et que lorsque ladite valeur moyenne ou ladite valeur intégrée est inférieure à ladite valeur cible, la durée d'application dudit courant de base augmente et que la durée d'application dudit courant pulsé diminue simultanément en fonction de la différence entre celles-ci.

4. Procédé de soudage à l'arc à courant pulsé selon la revendication 1, dans lequel ladite longueur de l'arc est déterminée de façon que lorsque ladite valeur moyenne ou ladite valeur intégrée est supérieure à ladite valeur cible, les durées respectives d'application dudit courant de base et dudit courant pulsé soient réduites en fonction de la différence entre celles-ci, et que lorsque ladite valeur moyenne ou ladite valeur intégrée est inférieure à ladite valeur cible, les durées respectives d'application dudit courant de base et dudit courant pulsé augmentent en fonction de la différence entre celles-ci.

5. Procédé de soudage à l'arc à courant pulsé selon la revendication 1, dans lequel ladite longueur d'arc est déterminée de façon que lorsque ladite valeur moyenne ou ladite valeur intégrée est supérieure à ladite valeur cible, la durée d'application dudit courant pulsé augmente en fonction de la différence entre celles-ci et que, si ladite valeur moyenne ou ladite valeur intégrée est inférieure à ladite valeur cible, la durée d'application dudit courant pulsé diminue en fonction de la différence entre celles-ci..

6. Appareil de soudage à l'arc à courant pulsé pour soudage par application d'un courant pulsé et d'un courant de base en alternance à une électrode consommable (2) et un métal de base (1), comprenant :

un moyen (9, 20) de détection de court-circuit servant à détecter un moment pendant lequel un court-circuit produit par fusion de ladite électrode consommable dans ladite électrode consommable (2) et ledit métal de base (1) est généré ;

caractérisé en ce qu'il comprend en outre un moyen de comparaison (20, 21, 22, 23) servant à comparer une valeur intégrée ou une valeur moyenne d'un moment de génération de court-circuit détecté par le moyen de détection de court-circuit, avec une valeur cible ; et

un moyen de commande (11, 14, 16, 24) servant à commander une durée d'application dudit courant pulsé et/ou une durée d'application dudit courant de base en fonction d'un résultat de la comparaison faite par ledit moyen de comparaison.

7. Appareil de soudage à l'arc à courant pulsé selon la revendication 6, dans lequel ledit moyen de comparaison comprend :

un dispositif de réglage (17) de temps de base servant à établir la durée d'application du courant de base ;
un dispositif de réglage (15) de durée d'impulsion servant à régler la durée d'application du courant pulsé ;
un additionneur (22) servant à obtenir une différence entre un moment (T_s) de court-circuit détecté par le moyen de détection (20) de court-circuit et un moment de réglage prédéterminé de court-circuit ;
un calculateur 23 de valeur intégrée/moyenne servant à générer une valeur intégrée ou une valeur moyenne de la différence obtenue par ledit additionneur (22) ;
un régulateur (16) de temps de base qui accroît et/ou réduit la durée d'application dudit courant de base à partir dudit dispositif de réglage (17) de temps de base en fonction de ladite valeur intégrée ou de ladite valeur moyenne et obtenant un moment de fin d'application du courant de base ;
un sélecteur (24) qui se ferme au moment de la réception de ladite valeur intégrée ou de ladite valeur moyenne fournie par ledit calculateur (23) de valeur intégrée/moyenne ; et
un régulateur (14) de durée d'impulsion servant à recevoir ladite valeur intégrée ou ladite valeur moyenne par

l'intermédiaire dudit sélecteur (24), accroître et/ou réduire la durée d'application dudit courant impulsionnel fourni par ledit dispositif de réglage (15) de durée d'impulsion, et obtenir un moment pour arrêter l'application du courant pulsé.

8. Appareil de soudage à l'arc à courant pulsé selon la revendication 6, dans lequel ledit moyen de comparaison comprend :

un dispositif de réglage (17) de temps de base servant à régler la durée d'application du courant de base ;
un dispositif de réglage (15) de durée d'impulsion servant à régler la durée d'application du courant pulsé ;
un additionneur (22) servant à obtenir une différence entre un moment de court-circuit détecté par ledit moyen de détection (20) de court-circuit et une durée de réglage de court-circuit calculée en fonction de la durée d'application du courant de base à partir dudit dispositif de réglage (17) de temps de base ;
un calculateur (23) de valeur intégrée/moyenne servant à générer une valeur intégrée ou une valeur moyenne de différence fournie par ledit additionneur (22); et
un régulateur (14) de durée d'impulsion pour accroître et/ou réduire la durée d'application dudit courant pulsé à partir dudit dispositif de réglage (15) de durée d'impulsion en fonction de ladite valeur intégrée ou de ladite valeur moyenne, et pour obtenir un moment d'arrêt de l'application du courant pulsé.

9. Appareil de soudage à l'arc à courant pulsé selon la revendication 6, dans lequel ledit moyen de comparaison comprend :

un dispositif de réglage (17) de temps de base servant à régler la durée d'application du courant de base ;
un dispositif de réglage (15) de durée d'impulsion servant à régler la durée d'application du courant pulsé ;
un additionneur (22) servant à obtenir une différence entre une durée (T_s) de court-circuit détectée par ledit moyen de détection (20) de court-circuit et une durée prédéterminée de réglage de court-circuit ;
un calculateur 23 de valeur intégrée/moyenne servant à générer une valeur intégrée ou une valeur moyenne de la différence fournie par ledit additionneur (22);
un régulateur (16) de temps de base pour accroître et/ou réduire la durée d'application dudit courant de base fourni par le dispositif de réglage (17) de temps de base en fonction de ladite valeur intégrée ou de ladite valeur moyenne et pour obtenir un moment d'arrêt d'application du courant de base ;
un premier sélecteur (24) qui se ferme au moment de la réception de ladite valeur intégrée ou de ladite valeur moyenne fournie par ledit calculateur (23) de valeur intégrée/moyenne ;
un premier régulateur (14) de durée d'impulsion servant à recevoir ladite valeur intégrée ou ladite valeur moyenne par l'intermédiaire dudit premier sélecteur (24), à recevoir ladite durée d'application de courant pulsé à partir dudit dispositif de réglage (15) de durée d'impulsion lorsqu'un second sélecteur (24') est dans un premier état, et à réduire une durée d'impulsion lorsque ladite valeur intégrée ou ladite valeur moyenne est positive et à accroître une durée d'impulsion lorsque la valeur intégrée ou la valeur moyenne est négative ; et
un second régulateur (14') de durée d'impulsion servant à recevoir ladite valeur intégrée ou ladite valeur moyenne par l'intermédiaire dudit premier sélecteur (24), à recevoir ladite durée d'application de courant pulsé à partir dudit dispositif de réglage (15) de durée d'impulsion lorsque ledit second sélecteur (24') est dans un second état, et à accroître une durée d'impulsion lorsque ladite valeur intégrée ou ladite valeur moyenne est positive et à réduire une durée d'impulsion lorsque la valeur intégrée ou la valeur moyenne est négative ;
grâce à quoi lesdits premier et second régulateurs (14, 14') de durée d'impulsion obtiennent un moment pour arrêter respectivement l'application du courant pulsé.

10. Appareil de soudage à l'arc à courant pulsé selon la revendication 6, dans lequel ledit moyen de détection de court-circuit, ledit moyen de comparaison et ledit moyen de commande fonctionnent sur la base d'un système à tension constante.

11. Appareil de soudage à l'arc à courant pulsé selon la revendication 6, dans lequel ledit moyen de détection de court-circuit, ledit moyen de comparaison et ledit moyen de commande fonctionnent sur la base d'un système à intensité constante.

FIG.1

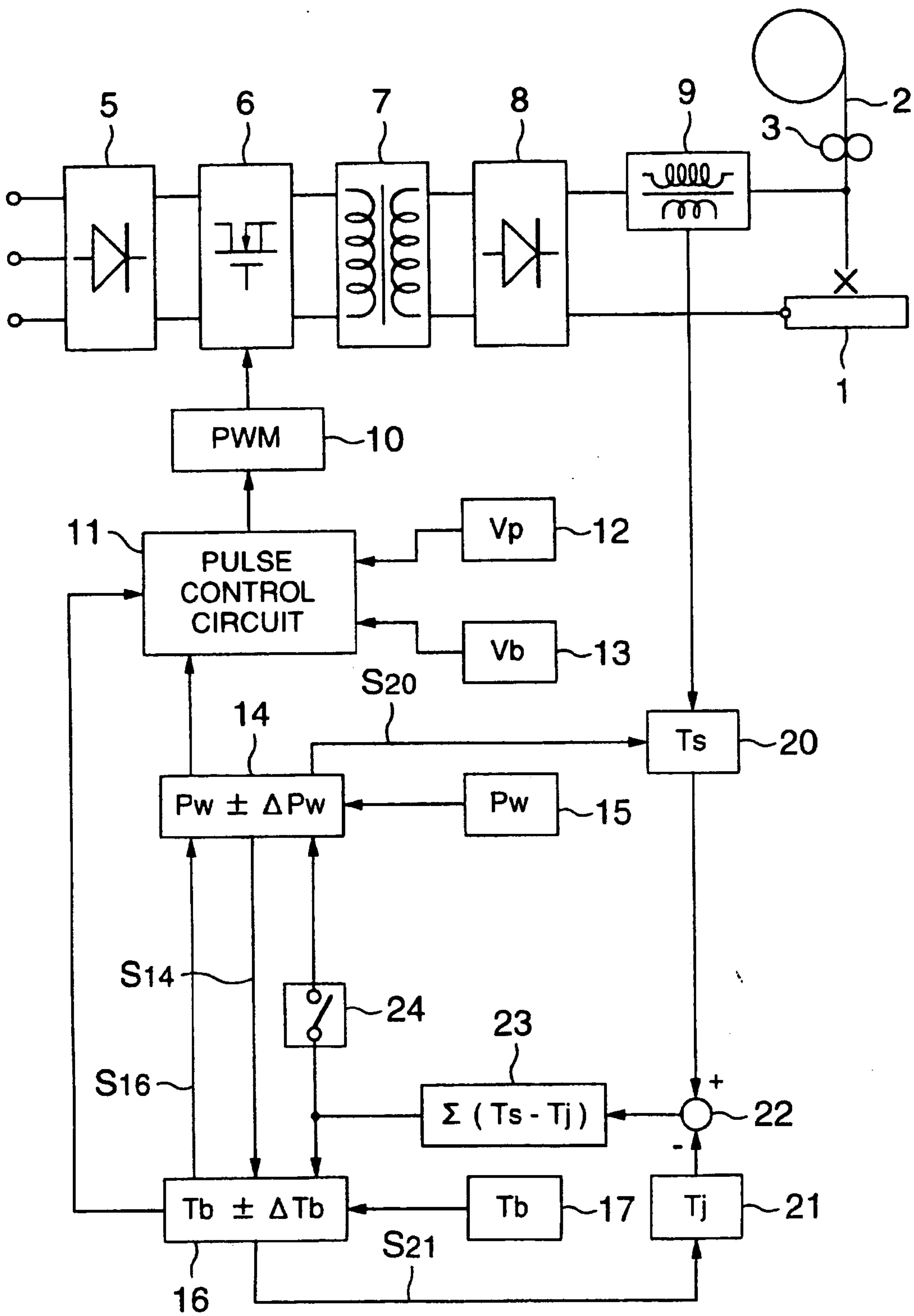

5
6
7
8
9
2
3
1
PWM
10
11
PULSE
CONTROL
CIRCUIT
Vp
12
Vb
13
S20
14
Ts
20
Pw ± ΔPw
Pw
15
S14
24
23
S16
Σ (Ts - Tj)
+
22
-
Tb ± ΔTb
Tb
17
Tj
21
S21
16

FIG.2

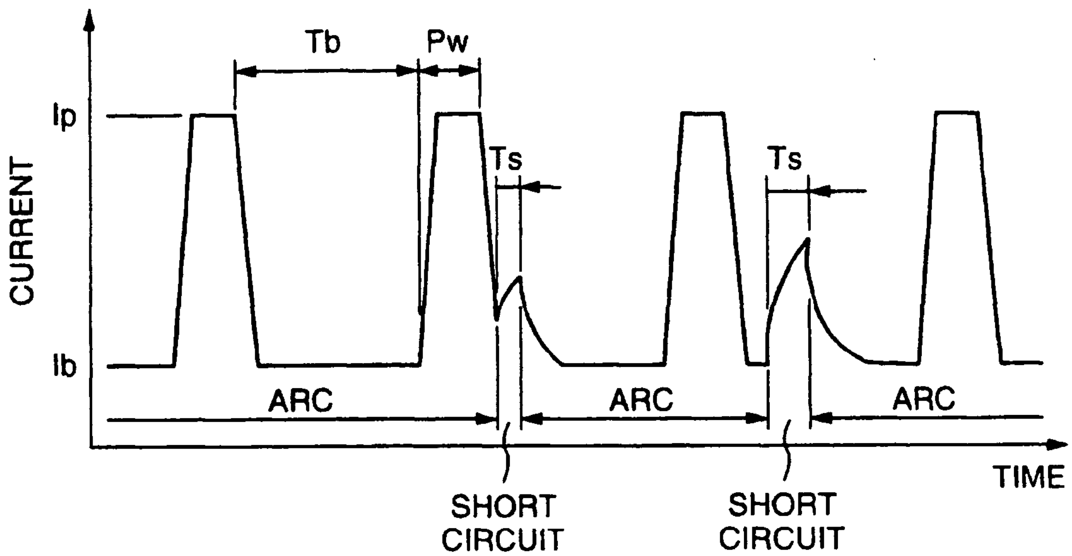

Tb
Pw
Ip
Ts
Ts
CURRENT
Ib
ARC
ARC
ARC
TIME
SHORT CIRCUIT
SHORT CIRCUIT

FIG.3

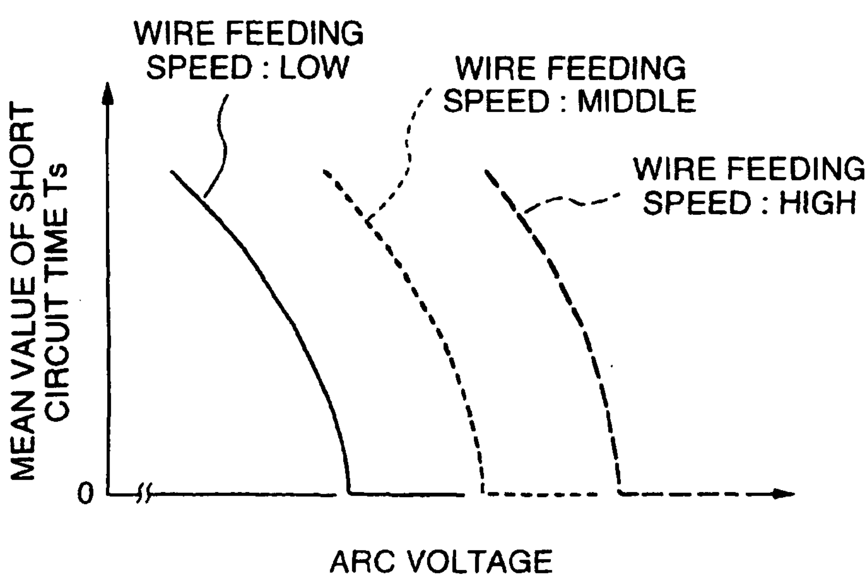

WIRE FEEDING SPEED : LOW
WIRE FEEDING SPEED : MIDDLE
WIRE FEEDING SPEED : HIGH
MEAN VALUE OF SHORT CIRCUIT TIME Ts
0
ARC VOLTAGE

FIG.4

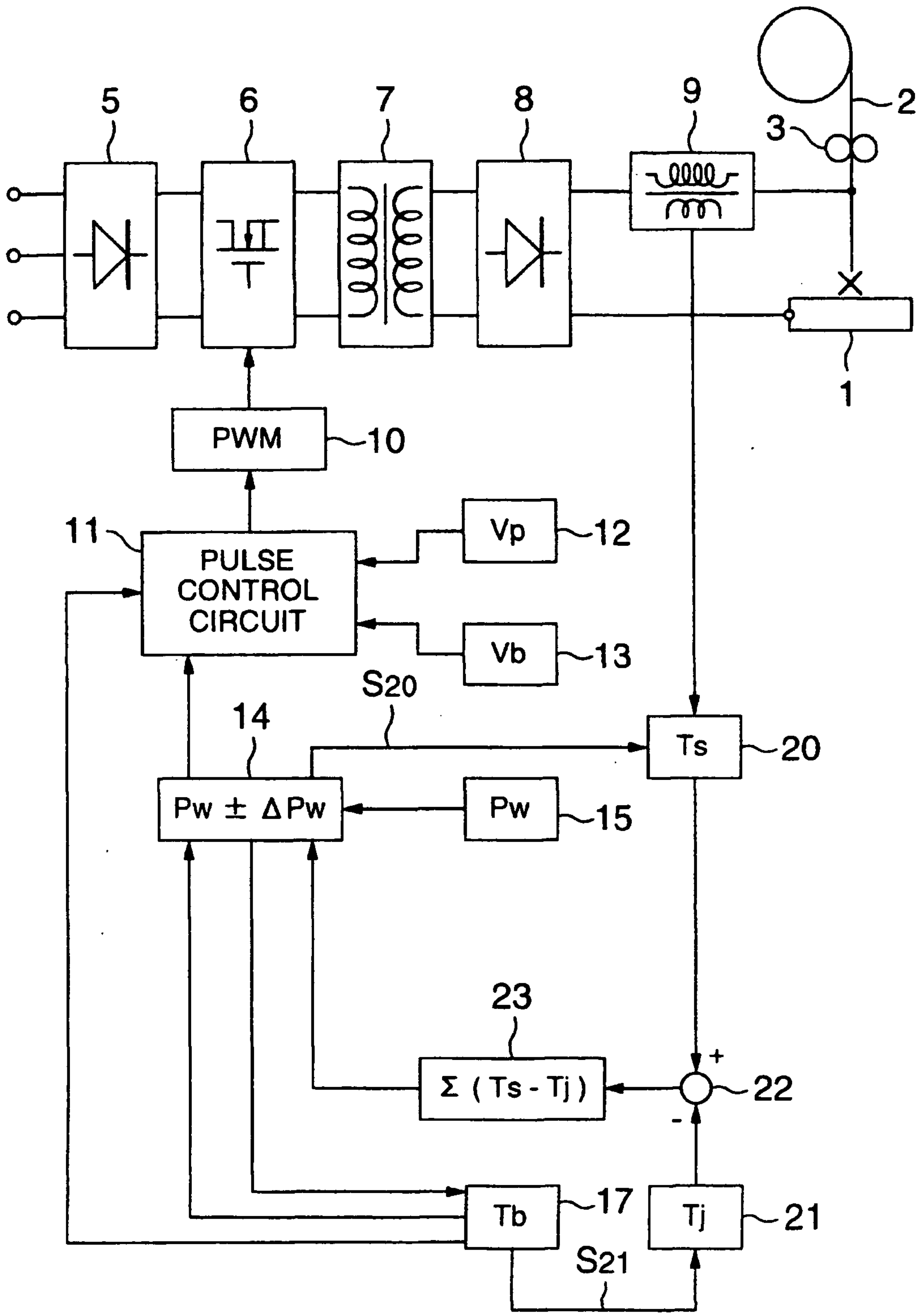

5
6
7
8
9
2
3
1
PWM
10
11
PULSE CONTROL CIRCUIT
Vp
12
Vb
13
S20
14
Ts
20
Pw ± ΔPw
Pw
15
23
+
Σ (Ts - Tj)
22
-
Tb
17
Tj
21
S21

FIG.5

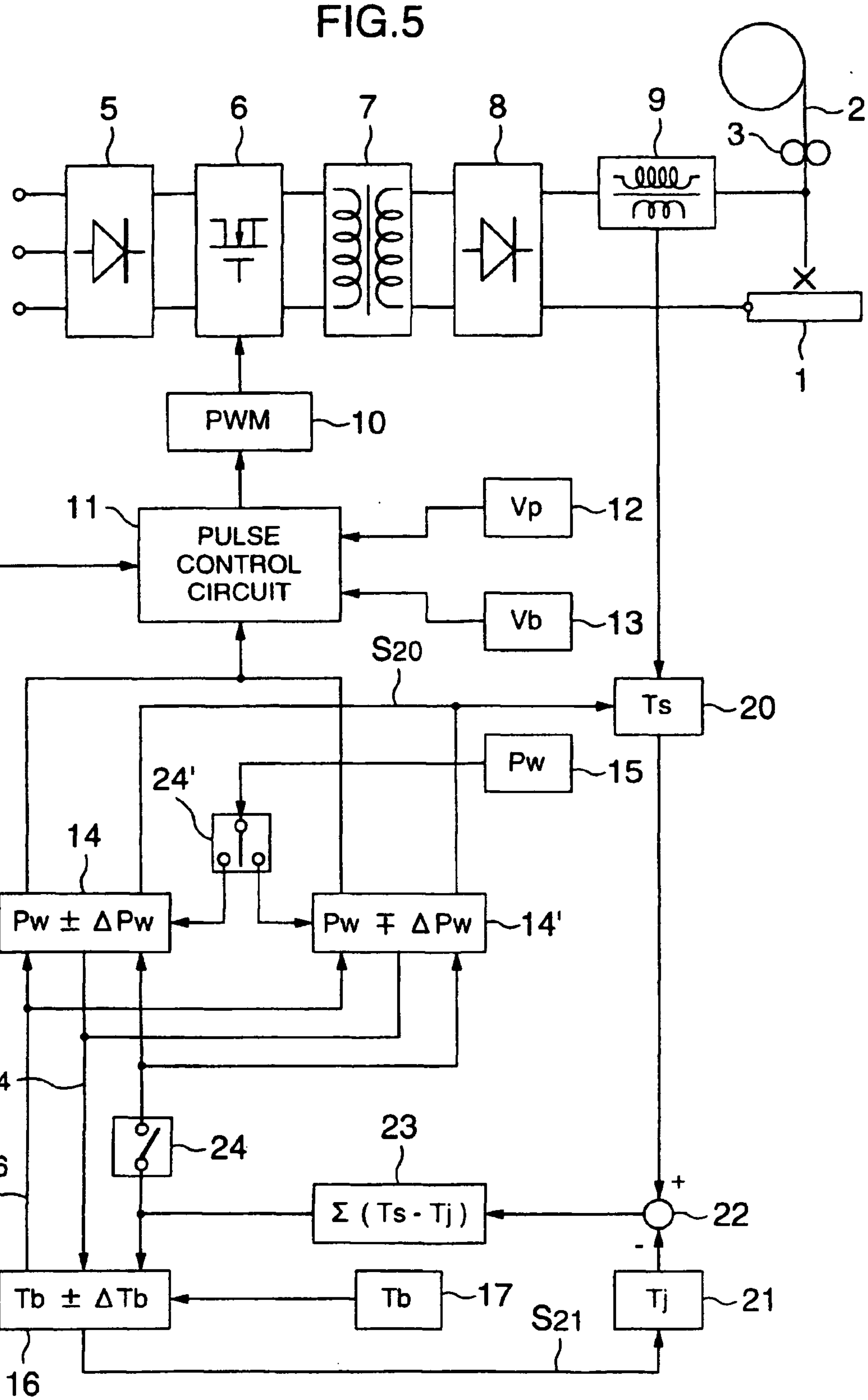
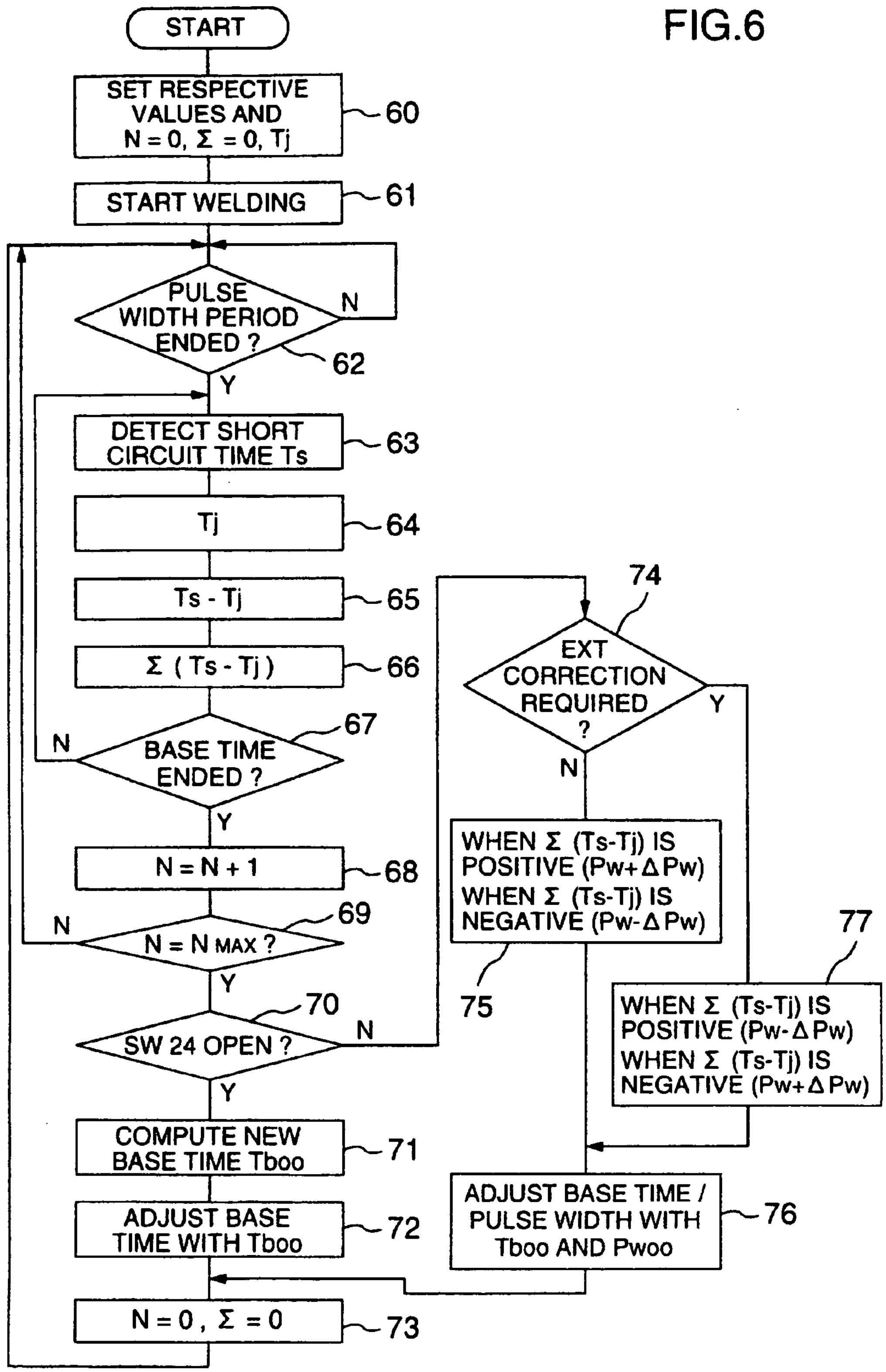

5
6
7
8
9
2
3
1
PWM
10
11
PULSE CONTROL CIRCUIT
Vp
12
Vb
13
S20
Ts
20
Pw
15
24'
14
Pw ± ΔPw
Pw ∓ ΔPw
14'
S14
24
23
S16
Σ (Ts - Tj)
22
Tb ± ΔTb
Tb
17
S21
Tj
21
16

FIG.6


START
SET RESPECTIVE VALUES AND N = 0, Σ = 0, Tj
60
START WELDING
61
PULSE WIDTH PERIOD ENDED ?
62
N
Y
DETECT SHORT CIRCUIT TIME Ts
63
Tj
64
Ts - Tj
65
Σ (Ts - Tj)
66
BASE TIME ENDED ?
67
N
Y
N = N + 1
68
N = N MAX ?
69
N
Y
SW 24 OPEN ?
70
N
Y
COMPUTE NEW BASE TIME Tboo
71
ADJUST BASE TIME WITH Tboo
72
N = 0 , Σ = 0
73
EXT CORRECTION REQUIRED ?
74
Y
N
WHEN Σ (Ts-Tj) IS POSITIVE (Pw+ΔPw)
WHEN Σ (Ts-Tj) IS NEGATIVE (Pw-ΔPw)
75
WHEN Σ (Ts-Tj) IS POSITIVE (Pw-ΔPw)
WHEN Σ (Ts-Tj) IS NEGATIVE (Pw+ΔPw)
77
ADJUST BASE TIME / PULSE WIDTH WITH Tboo AND Pwoo
76